TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM

Project Summary Report 0-4969-S
URL: http://tti.tamu.edu/documents/0-4969-S.pdf

Project 0-4969: Wireline Communications Design Guidebook for Intelligent Transportation Systems

Authors: Robert E. Brydia, Byron E. Brackin, Jeremy D. Johnson, Gary B. Thomas, and Kevin N. Balke

PROJECT SUMMARY REPORT

# Wireline Communications Workshop for Intelligent Transportation System Applications

Texas Department of Transportation (TxDOT) engineers are responsible for the design, evaluation, and implementation of intelligent transportation system (ITS) solutions across the entire state. These installations occur with vast differences in requirements, expectations, and constraints. Many deployments require some type of communication system to complete the installation.

This project developed a communications design methodology for ITS deployments, a reference guidebook, and training workshop materials. The project goals were to:

- establish a fundamental level of understanding of wireline communications concepts and technologies;
- create, deliver, and explain a comprehensive procedure for assessing communications needs for ITS deployments; and
- create a set of workshop materials for future training program opportunities.

## What We Did…

### The Basics of Wireline Communications

Researchers first surveyed a variety of literature to determine the most appropriate topics for creating a fundamental base of communications knowledge. Subjects covered in the guidebook and workshop materials included:

- the concept of information;
- analog versus digital;
- the transfer of information;
- bits, bytes, and more;
- bandwidth;
- media (shown in Figure 1);
- protocols;
- topologies;
- architecture;
- National Transportation Communications for ITS Protocol (NTCIP); and
- many other topics.

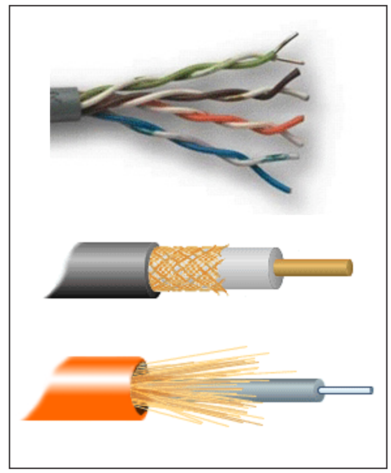

Figure 1. Media Types Covered in Workshop Materials.

### ITS Communications Solutions

Researchers identified the most common technology solutions utilized in the ITS arena. These include:

- serial (RS-232, RS-422, and RS-485),
- Plain Old Telephone System (POTS),
- Integrated Services Digital Network (ISDN),
- Digital Subscriber Line (DSL),
- cable modem,
- T-1/T-3 services,
- Asynchronous Transfer Mode (ATM),
- Synchronous Optical Network (SONET), and
- Ethernet.

Detailed information was provided on each technology choice, covering items such as typical applications, deployment scenarios, costs, bandwidth, and constraints. Of particular usefulness to engineers were the cross-technology tabulations of critical aspects of the communications solutions. Included are such items as:

- bandwidth,
- wiring,
- deployment method,
- distance limitations, and
- typical costs.

Table 1 shows a cross-technology tabulation for bandwidth. The table clearly defines both upload and download speed expectations at both theoretical and usable limits.

### Design/Evaluation Methodology

A main result of the project was a design/evaluation methodology, which covers both data and video applications. This methodology provides TxDOT engineers with a systematic procedure for:

- device accounting,
- bandwidth determination,
- evaluation of latency effects,
- suggested communications solutions, and
- typical design and deployment scenarios.

A sample page from the data communications worksheet is shown in Figure 2. Created in a tax table worksheet format, the methodology is straightforward and easy to use.

Table 1. Cross-Technology Tabulation of Bandwidth.

| Protocol | Bandwidth | | | |
|---|---|---|---|---|
| | Theoretical | | Typical (Usable) | |
| Serial | Up to 115.2 Kbps | | 19.2 Kbps | |
| POTS | 56 Kbps | | 40–45 Kbps | |
| ISDN | BRI – 128 Kbps<br>PRI – 1.544 Mbps | | BRI – 128 Kbps<br>PRI – 1.544 Mbps | |
| DSL | Download | 1.544–52.8 Mbps | Download | 1–8 Mbps |
| | Upload | 128 Kbps – 4 Mbps | Upload | 128 Kbps – 1 Mbps |
| Cable Modem | Download | 1–8 Mbps | Download | 1–4 Mbps |
| | Upload | 128 Kbps – 4 Mbps | Upload | 128 Kbps – 1 Mbps |
| T-1/T-3 | 1.544–44.736 Mbps | | 1.544–44.736 Mbps | |
| ATM | 1.54–622 Mbps | | Up to 500 Mbps | |
| Ethernet | 10 Mbps | | 4–5 Mbps | |
| | 100 Mbps | | 40–50 Mbps | |
| | 1000 Mbps | | 800 Mbps | |
| | 10,000 Mbps | | 8000 Mbps | |
| SONET | 51.84 Mbps – 39.812 Gbps | | 51.84 Mbps – 39.812 Gbps | |

## Workshop Materials

Products of the research project included a comprehensive set of materials for a communications workshop, as shown in Figure 3. A pilot of the workshop was taught and evaluated with extremely high marks for content, delivery, and professionalism of materials. The workshop materials also present case studies of both the data and video methodologies.

## What We Found…

The results of this project prove that it is feasible to create and apply a system design/ evaluation process for ITS communications needs. This process and the accompanying workshop materials are a solid base that can be built upon by application and case studies.

## The Researchers Recommend…

The success of the pilot workshop suggests that there is a strong need for this information and process to be disseminated across the state. Workshop materials are now available for this purpose.

**Data Communications Design Worksheet**

**Presence of Video Streams** *(Section 5.4.1)*

1. Are video streams in use now or will they be in the future?
   ☐ YES ☐ NO
   If 'NO,' proceed to Question 3. — 1.

2. Are the video streams and data being transmitted together over the same communications system in the field?
   ☐ YES ☐ NO
   If 'YES,' you do not need this worksheet, you need the Digital Video Communications Design Worksheet.
   If 'NO,' proceed to Question 3. — 2.

**Number of Devices** *(Section 5.4.2)*

3. How many of the following devices do you have?

| | Device Type | Number of Devices: Current | Number of Devices: Future |
|---|---|---|---|
| 3a. | Dynamic Message Signs | | |
| 3b. | Vehicle/Roadway Detectors | | |
| 3c. | TxDOT LCU | | |
| 3d. | TxDOT SCU | | |
| 3e. | RWIS | | |
| 3f. | Weather Stations | | |
| 3g. | Ramp Meters | | |
| 3h | PTZ Camera | | |
| 3i | Traffic Controllers | | |
| 3j. | Other | | |
| 3k. | *Subtotals* | | |
| 3l. | *TOTAL NUMBER OF DATA STREAMS (Add 3k CURRENT + 3k FUTURE)* | | |

TOTAL NUMBER OF DEVICES — 3m.

**Raw Data Bandwidth** *(Section 5.4.3)*

4. FOR ALL DEVICES, ASSUME CONSTANT TRANSMISSION

| | | Rate | Number | Bandwidth |
|---|---|---|---|---|
| 4a. | **Known Data Bandwidth Calculation** *For devices with known rates enter the rate and number.* | | | |
| 4b. | **Unknown Data Bandwidth Calculation** *For devices with unknown rates use 9.6 Kbps.* | | | |
| 4c. | **Total Bandwidth** *Total number should match line 3m.* | | | |

TOTAL RAW DATA BANDWIDTH (Kbps) — 4d.

Figure 2. Sample Page from Data Communications Worksheet.


Figure 3. Workshop Materials.

## For More Details...

The research is documented in:

Report 0-4969-1, *Development of a Wireline Communications Design Guidebook for Intelligent Transportation Systems*

**Research Supervisor:** Robert E. Brydia, TTI, r-brydia@tamu.edu, (979) 845-8140

**Researcher:** Gary B. Thomas, TTI, g-thomas@tamu.edu, (979) 458-3263

**TxDOT Project Director:** Steve Barnett, TxDOT, sbarnet@dot.state.tx.us, (512) 506-5113

**TxDOT Research Engineer:** Wade Odell, wodell@dot.state.tx.us, (512) 465-7403

**To obtain copies of reports, contact Nancy Pippin, Texas Transportation Institute, TTI Communications, at (979) 458-0481 or n-pippin@ttimail.tamu.edu. See our online catalog at http://tti.tamu.edu.**

YOUR INVOLVEMENT IS WELCOME!

## Disclaimer



PSR 0-4969-S

Texas Transportation Institute/TTI Communications
The Texas A&M University System
3135 TAMU
College Station, TX 77843-3135